Designing Hillside Protection Studies: Criteria for Assessing Environmental and Visual Value

Robin Corathers

"All too often in this country we think we have two choices....to buy land and lock it up forever in a park or a preserve, or to let anything-goes, horrible, schlocky development occur right next door. Those are not the only choices we have in this country. There is a third choice, and that is we can have growth and development that respects the character of a place and respects and enhances the character of our landscape." [Edward T. McMahon, director, American Greenways Program, The Conservation Fund November 25, 1991 at The Hillside Trust's "Hillside Protection Strategies" conference in Cincinnati, Ohio.]

The Greater Cincinnati metropolitan area in southwest Ohio and northern Kentucky is graced with an extraordinary network of rivers and green hillsides formed thousands of years ago by three different glaciers. The forested hillsides and the river systems give the region a unique visual personality and contribute significantly to the area's quality of life. This hillside system provides aesthetic, economic and environmental benefits to the urban region. The ribbons of green open space offer spectacular views and opportunities for outdoor recreation within an urban setting. Real estate values for areas with views, or adjacent to or near unspoiled slopes, remain high. The hillsides are an integral part of the urban ecosystem, providing wildlife habitat and migration corridors as well as relief from air pollution caused by urban congestion. The forested slopes prevent soil erosion and flooding and help conserve energy by shading buildings in summer and blocking cold winds in winter.

The hillsides are also quite fragile; Greater Cincinnati is known for its costly landslides. U.S. Geological Survey studies indicate the costs of landslide damage to private property and public infrastructure in the Cincinnati area are in the millions of dollars annually. The geological history of the region has resulted in an abundance of steep valley slopes, consisting of glacial clays and till, atop bedrock formations containing high percentages of shale. Many hillsides, particularly along the Ohio River, are not yet in a state of geological equilibrium, a condition geologists call "immature topography." These factors, together with a high average annual rainfall, contribute to the area's many landslides. But it has been insensitive development--cutting into the toes of slopes, placing fill on slopes, regrading and paving without controlled drainage--which has triggered the vast majority of landslides.

In addition to landslide damage, insensitive development and poor design have changed the visual character of the hillsides and destroyed valuable natural areas. Until about fifteen years ago, the region's hillslopes remained largely undeveloped, with most construction occurring in valley bottoms and on hilltops. In the past decade, however, development pressures for even the steepest slopes have sharply increased due to several factors including growing scarcity of undeveloped flat land; technological advances in earth movement and retention methods; and the increasing number of people who want and can afford properties with a view.

About fifteen years ago, the city of Cincinnati recognized the potential danger of insensitive development. It authorized, by ordinance, the creation of a series of

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This article is based in part on The Hillside Trust's publication principally authored by Samuel V. Noe, an architect and professor in the School of Planning at the University of Cincinnati. Noe is a board member of The Hillside Trust.

"Environmental Quality (EQ) Hillside Districts," a zoning overlay within which protective measures could be established. To date only half of the hillsides in the city have been designated as EQ Hillside Districts, and in most of the region the need for hillside protection has not been addressed at all.

Two factors have limited the adoption of rational and well-coordinated policies and enforcement of stringent regulations by local governments. Many government officials in the region have supported unlimited growth and have been reluctant to antagonize developers who they believe would oppose hillside protection measures. The lack of information about the "environmental and visual sensitivity" of hillsides within the various political jurisdictions located in the Greater Cincinnati metropolitan region has further hampered protection efforts.

As this view form Price Hill illustrates, Cincinati's hillsides combine with the Ohio River to form a natural visual amenity.

In 1988, the Hillside Trust, a private nonprofit regional land conservation organization, began research to provide better information about the hillsides and better tools for both its internal decision-making and that of local governments and others concerned with hillside development and preservation. The Trust formulated the following research questions:

- How should the relative aesthetic qualities and environmental significance of hillsides in the metropolitan area be assessed?
- How can these distinctions be related to vulnerability to landslides and development?
- What are appropriate guidelines and regulations for cases where sensitive hillside development is possible?
- Which hillside areas deserve priority attention by the Hillside Trust and local governments?

The Hillside Trust recognized that a comprehensive approach to hillside protection was needed to guide sound decision-making. The Trust's staff and consultants designed two research projects: one documenting the relative sensitivity of hillside land and identifying critical natural areas for priority attention; and a second creating a model set of hillside development guidelines and regulations for adoption by local government.

The Hillside Trust proposed to study the impact of development type, density, design, and location factors on perceptions of visual quality and how to incorporate this information into planning guidelines, goals and objectives. The Trust contacted the U.S. Forest Service for technical and financial assistance. It was referred to the Forest Service's North Central Forest Experiment Station in Chicago, Illinois, which had done research on visual preferences and visual resource assessment methodology. The Forest Service had developed a Visual Management System for evaluating wilderness areas, but this methodology had never been adapted to urban environments nor incorporated into a geographic information system (GIS). Previous research by the North Central office in Cincinnati had shown that intense hillside development can negatively affect perceptions of visual quality.

The Forest Service expressed interest in this proposal and agreed to fund it through cooperative research grants. In addition to the Forest Service funding, the Hillside Trust was able to secure financial and in-kind service support for the two studies from eleven state and local government agencies and private foundations, and from scores of individual professionals and interested citizens who volunteered their expertise and time.

Although the geographic scope of the Trust's research is limited to the Greater Cincinnati region, its work should be of interest to elected officials, planning and zoning commissioners and staff, design and development professionals, park commissioners, civic leaders, and others concerned with land conservation and development issues in hilly terrain. In particular, the design of the Hillside Trust's studies and the development guidelines they generated can serve as a useful model for any community where visually and environ-

mentally sensitive hillside land is subject to development pressures.

GIS Study

The Hillside Trust decided to use a computer-based geographic information system (GIS) to provide a flexible and dynamic technique for identifying critical hillside areas. The Trust was particularly interested in using GIS to:

- analyze potential implications of alternative patterns of development and planning strategies;
- "zoom in" on specific sites within the electronic maps and conduct more detailed studies;
- allow government planners to adjust the parameters of the analytical models, based on new or different environmental data or different sets of assumptions;
- rapidly update data and produce maps at different scales.

Although the Hillside Trust is concerned with the protection of hillside resources in a five-county area in southwest Ohio and northern Kentucky, it limited its GIS study to hillsides in Hamilton County, Ohio and Kenton County, Kentucky, an area encompassing over 370,500 acres. This choice was made because of budget constraints and because these counties had their own GIS or are in the process of establishing one.

Research involved the design and testing of systematic computer-based models for mapping hillsides. The analytical models rate hillsides according to relative visual quality, landslide hazard, value as ecological corridors, and susceptibility to development. These classifications were then combined to produce six color-coded composite maps showing the relative sensitivity of hillside land to development.

The analytic models determined the data requirements for the study. Hillside Trust staff collected existing information from a great range of original mapping scales and map types. Landsat satellite imagery was used to update land use/land cover information. The map coordinate system selected was Universal Transverse Mercator (UTM). ERDAS GIS software was chosen for use in digitizing map information into the GIS because of its efficiency and speed. This transformation process was closely monitored because of inaccuracies in some of the original maps.

The Trust hired Dr. Douglas Way, a landscape architect and consulting principal of the SWA Group, Columbus, Ohio, to develop the analytical models in consultation with the Hillside Trust staff and an advisory committee, which included representatives from all the supporting organizations. Dr. Way produced a series of primary and summary maps of hillside characteristics for the project.

Analytical Composite Maps

Visual Sensitivity. An analytical model was developed to determine the relative visual quality of hillsides as a function of land use/land cover, proximity to water, diversity of positive landscape elements, and location along the hillside upland edge (the area most critical to visual impact.) Natural, undeveloped areas that are close to water, with a combined view of forests, water, agricultural land or pastures, and are located on the sensitive hillslope rim were rated highest in visual quality and sensitivity.

Landslide Potential. Geological information, degree of slope, and evidence of previous landslides were used to determine relative landslide hazard. In the Greater Cincinnati region, landslides are most likely to occur over the Fairview and Kope bedrock formations, which contain up to eighty percent shale. Slope instability is also associated with areas located above lacustrine clays. Steepness of slope and proximity to existing areas of instability are the other primary variables in determining landslide susceptibility.

Ecological Corridors. While studies in other parts of the country have documented the importance of forested areas in filtering particulates from the air and absorbing and storing carbon dioxide, in moderating temperatures, and in preventing erosion and flooding problems, little data of this variety

Extensive grading of hillsides makes them susceptible to landslides and erosion.

was available in the Cincinnati area. After conferring with biologists and other scientists, the Hillside Trust instead decided to focus on the region's pattern of ecological corridors which sustain an abundance and variety of wildlife.

The relative importance of each hillside as an ecological corridor was determined by examining land characteristics (upland, rim, slope, valley), proximity to water, land use/land cover, and, where documented, the presence of threatened and endangered species. The most ecologically significant zones are found in linear patterns following the valley systems, along the lower edges of the hillslopes, adjacent to or near streams, and in areas least disturbed by development.

Development Susceptibility. Susceptibility to development was determined to be a function of proximity to existing or proposed infrastructure, including major roads, water and sewer lines; construction costs determined by topographic slope and flood hazard; and visual amenities including view potential from hillside edges and valley slopes.

Summary Maps

Visual and Environmental Sensitivities. To identify critical hillside areas, a composite map was generated that identifies hillsides with high visual sensitivity, high quality ecological corridors, and high landslide potential. This analysis provides multiple justification for protection of these areas through permanent preservation methods and through use of more stringent controls over any future proposed development.

Hillside Action Priorities. As an additional planning tool, the summary map of visual and environmental sensitivities was overlaid on the map of development susceptibility to identify where high quality sensitive hillside areas are also susceptible to future development. This composite map locates higher quality hillsides that are under less pressure at the present time for development and may therefore be less expensive to acquire, as well as hillsides of relatively low visual and environmental sensitivity where it would be appropriate for local governments to direct future development.

Detailed Small Area Analysis

To demonstrate future applications of the GIS-generated data base for local planning decisions, the Hillside Trust chose a "micro" area spanning the Ohio River and illustrated how a hypothetical study could be conducted for parkland acquisition. The detailed model illustrates the change in scale from regional analysis to site-specific study, using the output of the "macro" analysis while also including appropriate "micro" information.

In this example, desirable land was defined as all undeveloped parcels larger than one acre, rated as having high visual sensitivity or high quality as an ecological corridor and rated as having a high susceptibility to landslides. To this was added more detailed site information including analysis of soil types and their limitations for development; the quality of tree stands as evaluated by a U.S. Forest Service landscape architect who visited and mapped the sites; and information on zoning, land ownership, mean value of parcels, and proximity to major roads.

Development Guidelines

The Hillside Trust used several research methods to formulate appropriate guidelines for development in sensitive hillside areas (see figure 1):

- survey and evaluation of legislation in use by cities and counties with similar topographic features throughout the United States;
- consultation with environmental, development, planning and legal professionals;
- adaptation of the U.S. Forest Service's visual preference methodology, focusing on a number of develop-

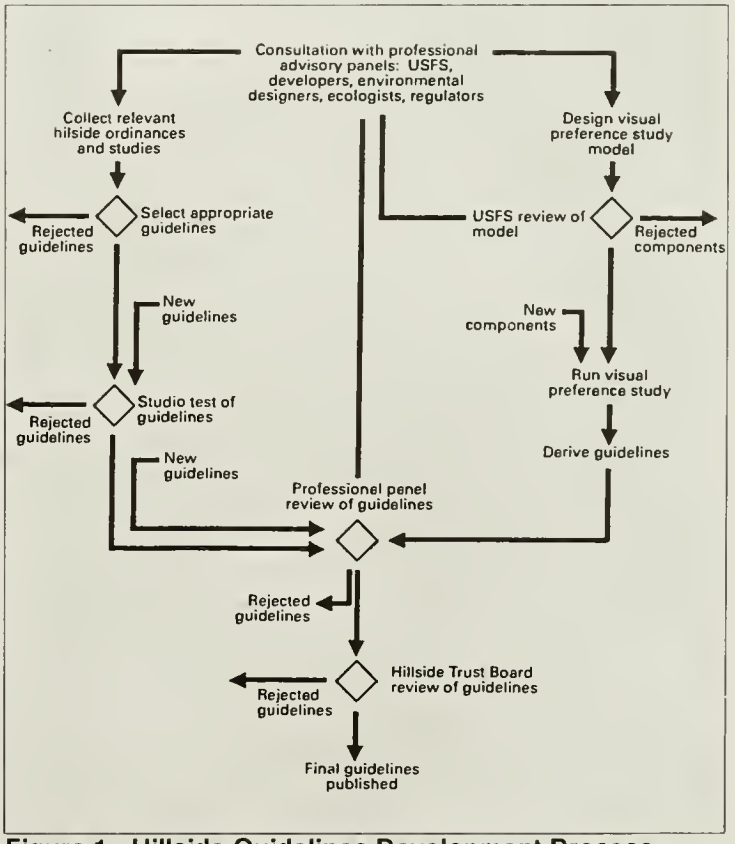


Figure 1. Hillside Guidelines Development Process

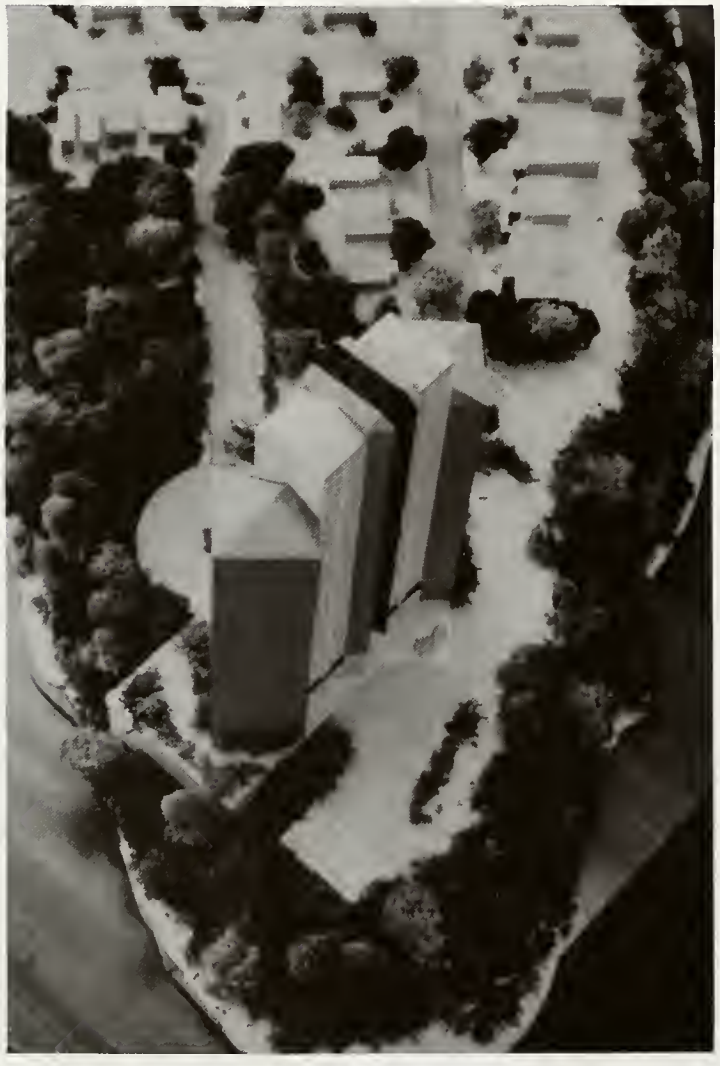
ment variables and their visual impact in an urban environment;

- testing of packages of guidelines in a University of Cincinnati studio of advanced architecture and planning students, supervised by respected developers in the region.

Guidelines Derived from Existing Ordinances. Provisions of ordinances from around the country were classified by type, relative degree of importance, and type of legislative or policy vehicle in which they are most appropriately included. The guidelines determined to be most applicable to Greater Cincinnati are a range of public policies; guidelines for regulation of subdivisions of hillside land; zoning to regulate density of hillside development; zoning to regulate the visual character of hillside development; earthwork, erosion, drainage and sedimentation controls; and retention and replanting of vegetation.

Guidelines Derived from the Visual Preference Study. The Hillside Trust incorporated public opinion into its research using a modified version of the U.S. Forest Service's visual preference technique. The results of the visual preference study provide an additional basis for recommending where green space should be maintained on the hillsides and where different types of buildings relate harmoniously with the natural environment. The conclusions drawn from the visual preference study also lend an additional measure of legitimacy to the recommended guidelines, because the guidelines embody the views of both a representative sample of local residents as well as professionals whose work involves different aspects of hillside development in the region.

The Trust hired John Decker, an architect, landscape architect, and professor at the School of Planning at the University of Cincinnati, to design and execute the visual preference research. The visual preference rating technique involved the creation of thirty views of characteristic hillsides, developed to different densities with a variety of building types, and sited in a range of different patterns. Most of the views were synthetically constructed, using a computer imaging processing system to overlay photographs of a range of building types on a photograph of an undeveloped hillside. This permitted virtually every likely pattern of hillside development in the collection of views.



Hilltop highrise development should be reserved for a few promontory points and be subject to rigorous design review to ensure proper hillcrest setbacks.

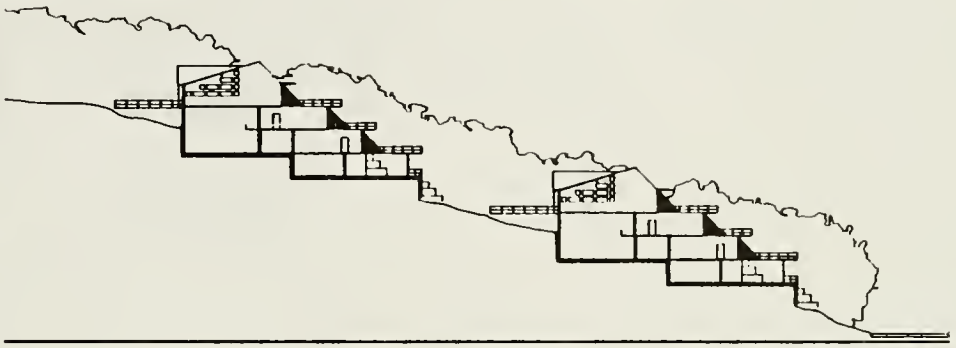
Lay and professional research participants were asked to indicate the extent to which they found each image either attractive or unattractive and, in cases of extreme reactions, the reasons for their feelings. The responses were then tabulated, and later used in the development of a number of guidelines.

After examining the thirty images, each respondent was asked to work with an operator of the computer imaging system to construct a preferred pattern of hillside development. The total collection of "ideal" development patterns on the same hillside were then superimposed on one another in order to locate the portions of the hillsides most often left free of development and the locations most commonly favored for different types of buildings.

The Hillside "Studio": Testing Guidelines in the Design Laboratory. Midway through the project, a number of promising approaches to regulation of hillside development began to emerge from the preliminary analysis of legislation in use in other parts of the country. These approaches were evaluated and compared in an urban design studio exercise at the University of Cincinnati to test their appropriateness to local conditions. In this exercise, four teams of advanced students from the Department of Architecture and the School of Planning were asked

to design housing developments on two prototypical Cincinnati sites.

Two of the teams were assigned an eight-acre mid-slope site in an inner suburban location. They were instructed to design approximately fifty dwelling units, with each team following a different package of development regulations. The other two teams were assigned a hillcrest site on a commanding ridge overlooking the Ohio River and downtown Cincinnati. They were also given different development regulations and asked to design between forty and one hundred dwelling units, in either a high-rise or a less obtrusive configuration. All teams were assigned a practicing residential property developer as a mentor and design critic.



Housing development appropriate to a mid-slope site located on an inner suburban hillside. Density has been kept low by clustering the units, leaving much of the forested hillside untouched.

During the exercise, the students were asked to evaluate the set of guidelines they were working with and to suggest revisions which might contribute to designs more compatible with the hillside environment. The design work continued based on these revised guidelines.

The range of architectural designs produced in the studio proved useful in determining appropriate locations for different types of buildings on the hillsides. The testing of the different development guidelines employed proved equally helpful. Some guidelines had the potential to place unreasonable economic burdens on project developers. Others, while preventing many forms of inappropriate development, also had the effect of constraining particularly imaginative and desirable approaches to design. This studio experience influenced final choices for recommended development guidelines, primarily by helping to discard less promising approaches.

Expert Consultation. Throughout the course of this project, the Hillside Trust consulted with a variety of hillside development professionals, including soil scientists, geologists and geotechnical engineers, landscape architects, architects, urban designers, ecologists, biologists, planning officials, developers, and attorneys.

These experts assisted in the design of the study, participated in workshops on development guidelines and seminars based on the studio work, served as subjects in the visual preference study, and reviewed drafts of the Hillside Trust's final report.

In all, 162 guidelines were generated from the study. The Hillside Trust believes some of these guidelines are essential to any local government's hillside protection program. Of particular note are the Trust's recommendations for public policies that call for designation of hillside protection overlay districts; establishment of hillside development review boards; public acquisition of fee simple title or conservation easements for critical hillside areas; and requirements that public and quasi-public agencies be bound by hillside protection measures in addition to private property owners. Other guidelines are recommended or optional and should be considered a menu from which local governments can pick and choose, depending on their own needs and unique circumstances.

Next Steps

The Hillside Trust announced the completion of its research projects in June, 1991, at its annual membership meeting, and received favorable local press coverage. Since that time, the organization has been working to familiarize elected officials, planning and zoning commissions and staff, design and development professionals, and concerned citizens with its findings and recommendations through public presentations and meetings. On November 25, 1991, The Hillside Trust held a day-long public conference entitled "Hillside Protection Strategies for Greater Cincinnati" which 175 professional and lay people from Kentucky and Ohio attended. Speakers covered topics from specific land conservation methods to regulating the quality of design for hillside development.

[Editor's note: A full account of project methodologies, findings and recommendations can be found in The Hillside Trust's three-volume publication A Hillside Protection Strategy for Greater Cincinnati. Copies of the three-volume set of books summarizing The Hillside Trust's research are available for $45 plus $5.50 for shipping and handling. Copies of the hillside development guidelines data base are available in either 3 1/2" or 5 1/4" floppy disks for $25 plus $3 for shipping and handling. For more information about The Hillside Trust's work, write or call:

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